

A Quantum Computer Simulator

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1 Background

Quantum computers are machines that work on a radically different principle to classical computers, making use of the properties of quantum physics to calculate some functions and simulate physical systems faster than any classical computer possibly could. Their memory consists of quantum bits or *qubits*. Unlike a classical bit which must be either 0 or 1, a qubit can be in a superposition of 0 and 1, or be entangled with another qubit.

Small (2–5 qubit) quantum computers have been built and studied in many physics laboratories around the world (including at MC2 here at Chalmers), and there are many efforts around the world to build larger quantum computers (including at MC2 here at Chalmers!)

Even before access to real quantum computers becomes common, we want to develop and test quantum algorithms. For this purpose, it is useful to *simulate* a quantum computer on a classical computer. Simulations typically take as input a quantum algorithm described in some appropriate language, and predict what the output would be if that algorithm were run on a quantum computer (but of course more slowly than a quantum computer would).

2 Project description

This project is about developing a simulation of a quantum computer. The end result should allow the user to input a description of a quantum algorithm in some appropriate form (e.g. code in a suitable language for describing quantum algorithms, or via a graphical interface). The simulator will then describe the outcomes of the measurements performed at the end of the algorithm. Other features that could be implemented include showing the internal states of the qubits at a time in the middle of the algorithm, allowing the user to roll time backwards and forwards in the simulation.

For a more advanced project, the simulator might be extended to a hybrid classical-quantum system: a classical computer that controls a quantum computer, deciding which quantum circuit to set up and execute depending on the outcomes of measurements from the previous circuit. Most of the interesting quantum algorithms (such as Shor's algorithm for factorizing integers) are algorithms for a hybrid classical-quantum system.

No prior knowledge of quantum computing is assumed, but proficiency in linear algebra is essential for learning the mathematics behind quantum computing. This project could be completed using any programming language.

3 Target groups

DV, D, IT.

4 Special prerequisites

Proficiency in linear algebra and complex numbers is required for this project.

5 Proposal Author

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6 Supervisor

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